What does your face tell me about you? Evidence of a hierarchy in the social categorization of faces

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Abstract

Social categorization is probably the most important mechanism identified in social psychology. We group the people with whom we interact into various social categories, which allows activating beliefs about them to adapt our social interactions. Here we tackle the fundamental question of how we process when multiple category memberships are available such as gender, ethnicity, age, and familiarity, with the hypothesis that all categories are activated in parallel and compete with each other, creating a hierarchy in our categorical perception. To analyze multiple categories processing, we adapted the Free Sorting Task (FST) to human face categorization. Based on nearly 150 participants, our hierarchical clustering analysis based on principal components coupled with multiple correspondence analysis clearly defines a hierarchy in social categorization, namely first age, then gender, and subsequently ethnicity and familiarity, nearly equally. Further, we demonstrated that emotion in facial expressions overwhelmingly outperforms all social information without changing the hierarchical order of the other social categories. Firstly, our adaptation of the FST allowed us to demonstrate how multiple categories are represented, which until now has been highly problematic in social psychology. Secondly, our results contradict the dogma that social category information is used before emotion categorization, and they demonstrate that during the conscious categorization task and in the case of multiple memberships, the social attributes of a human face, including emotion, are represented hierarchically.

Key words: social categorization; faces; social interaction; hierarchical

Introduction

Social categorization is probably the most important mechanism identified in social psychology to understand social interactions and how we set up responsive behavior with respect to others (Tafjel and Turner, 1979). When facing a person, rather than considering her/him in terms of her/his unique characteristics, we instead consider the person based on the social categories to which she/he belongs or, more precisely, to which we think he/she belongs. Indeed, people are almost automatically classified into sub-categories according to their gender, age, ethnicity, social status, …. a list of attributes that can be extremely long and whose specificity also depends on the perceiver's social category. Social categorization allows one to quickly make expectancies about others and oneself, forming a general conclusion about others. By allowing us to anticipate the intentions of the people we are communicating with, we can redirect attentional resources to other unexpected information that may occur (Macrae and Bodenhausen, 2000).

The negative consequence of social categorization is that it creates stereotypes to the detriment of objective information. Categorization based on stereotypes can lead to negative outcomes resulting in cultural, social, or sexual discrimination. Indeed, it can convey and amplify false beliefs about others, a process that is not necessarily intentional or even conscious (Thompson and Stangor, 2013). Finally, social categorization directly affects a large range of cognitive processes (attention, perception, memory, judgment) and behavior (Adolphs, 1999). As demonstrated by Tajfel & Wikles (Tajfel and Wilkes, 1963) in a perceptual task of dimension judgment of objects, categorization increases bias of contrast between categories and maximizes similarities inside categories.

One of the issues that social psychology studies have faced is the evidence that a person has several features that can define several categories. A person may have an appearance that places them in a specific socio-economic category while at the same time presenting a membership in broader categories such as gender or age. In this case, the different categories will compete, and some experimental procedures have suggested that a single categorization dominance would emerge. Nevertheless, such domination will depend on several factors, including the category's saliency, the perceiver's intentions, and the bias or prejudice concerning a specific category (Macrae et al., 1995).

One of the main approaches to evaluate cross-categorization processes was to use the 'Who Said That' paradigm with priming conditions, a protocol that can, unfortunately, be

misleading and raises difficulties in interpreting the data (Klauer and Wegener, 1998). While there was a general agreement about the existence of an inhibitory mechanism that would allow a single category to dominate (Macrae et al., 1995), new mouse-tracking technics that provide the dynamic of social categorization suggest some co-activation processing (Stolier and Freeman, 2016). The Social Identity Complexity theory (Roccas and Brewer, 2002) then proposes that categories are not mutually exclusive, leading to categories intersections which make it difficult to think in terms of a single category (see (Kang and Bodenhausen, 2015)). However, in most cases, multiple categories interactions depend highly on experimenter-induced protocol biases that impose a forced choice on the subjects (to categorize as a function of gender, age…). Altogether, this contextual dependence of most of the protocols on social categorization prevents us from determining whether or not there is a categorization hierarchy that would dictate our judgment of the person we are facing. Indeed, it is supposed that the broad categories of age, gender and ethnicity are automatically and unintentionally activated (Stolier and Freeman, 2016) partly because these categories are highly visible and highly available among people around us. From there, it is probably difficult to know what would be the dominant category given that low-level bottom-up sensory processes can also be involved.

This observation has been the primary motivation behind our study, namely to search among the criteria of gender, age, or ethnicity for the possibility that one specific category could dominate and which would first trigger our social interactions. Obviously, our interactions differ depending on whether we socialize with a child or an adult, and our relations with a young boy or girl can also be quite different.

For this reason, in the present study, we used a Free sorting Task (FST) protocol to assess the hierarchical organization between the main social categories used to discriminate human faces (i.e., ethnicity, gender, age). In the FST, participants group many items into categories according to their choice; therefore, this is a direct, comprehensive, and holistic method of categorizing objects. It has been used predominantly in consumer behavior studies (see (Courcoux et al., 2012)) but also in developmental psychology to address, for example, cognitive flexibility (Blaye et al., 2006), sound listening strategies (Berland et al., 2015) or emotion discrimination (Matthews et al., 2022). One of the strong advantages of the FST over explicit forced-choice tasks is the absence of instructions given to subjects and, thus, the absence of bias in the categories formed. In a face FST, the choice of subjects can lead to a

wide variety of possible criteria, whether in hair length, face attractiveness, or gaze direction. Subjects can form a single category or as many categories as they want; there are no limits or restrictions. Then the analysis computes the frequency of pair-wise co-occurrences of items combined among participants, further expressed as a hierarchical tree representation. Thus, when a hierarchical tree can be displayed at the group level, we can directly infer from it the major criterion and then the successive ones in competition. Then, a subsequent multiple correspondence analysis allows us to establish more precisely the distances that separate the different elements within and between categories.

In the context of social interaction, individuals not only categorize faces according to their social characteristics, but they also consider the facial expression of the face, as we rarely have to deal with neutral, expressionless faces. However, many studies show that the social category information carried by the face can interfere with the perception of different types of emotion (Carr et al., 2014). While subjects tend to be faster at detecting a face's happiness than a negative expression, this processing speed tends to vary according to the gender or ethnicity of the face (Hugenberg, 2005), leading to the conclusion that social categorization predominates over emotional processing. The main problem with this type of analysis is that it relies on the processing speed of different facial features, which may involve low-level visual processes (spatial frequency, for example) independently of social categorization processes (Morrison and Schyns, 2001). Again, it is important to seek how the emotional features of a face interact with social categorization in a more explicit approach differing from automatic treatments because interactions with people are dynamic phenomena and are constantly adjusted as the relationship progresses (Freeman and Ambady, 2010). Then, the second motivation of our study was to investigate how the emotions conveyed by a face influence the hierarchy in their social categorization.

In the present study, using a Free Sorting Task to categorize faces, we searched for a hierarchical processing of face attributes. We demonstrated that the emotions carried by the facial expressions constitute the main feature that subjects use to differentiate faces fitting into multiple social categories. Further, age and gender emerge as secondary criteria, while ethnicity or familiarity (in our case, the celebrity of the faces) appear as a last criterion. When social or emotional characteristics are removed or added, the relative order between the different characteristics does not change, reinforcing our hypothesis of a strong and probably fixed hierarchy in the representation of social and emotional categories.

Methods

Participants

Participants (n= 212) were young adult students (age range 19-32, 52% women); the participants' socio-economic status was rather homogenous, mostly under- and post-graduate students. The study was conducted according to the principles stated in the Declaration of Helsinki (2013) and was approved by the local research ethics committee (CPP Recherche Biomédicale Toulouse II Avis N˚2–03–34/Avis N˚2)

Stimuli

For each experiment (Table 1), a separate group of subjects was tested to avoid the effect of training. Each group of participants completed a Free Sorting Task (FST) of sixteen faces. All faces were presented in black and white and were normalized for size, intensity, and contrast. Each experiment had three criteria taken from the set of 5 criteria: Age, Gender, Ethnicity, Familiarity, and Emotions. Two images presented each smallest possible subgroup. For example, an Adult African Woman could be seen in two images of different people (see Table 1).

These criteria correspond to categories that have been described as the main basic categories (Stolier and Freeman, 2016): age (infant vs. adult), gender, ethnicity (African, Caucasian, or Asiatic), and familiarity (famous actors or singers vs unknown). In five experiments, to assess how the emotional content of faces can impact social categorization, stimuli were expressive faces: happy (smiling) or sad (crying) faces were presented in addition to the two other criteria (a smiling or crying famous female actor, for example). The combinations of the three criteria led to 8 different categories of stimuli. For example, in Experiment 3 there were 2 sad small girls, 2 sad small boys, 2 happy small girls, 2 happy small boys, 2 sad adult women, 2 sad adult men, 2 happy adult women, 2 happy adult men (see Figure 1A).

Table 1. Experiments and the demographic of the subjects

	Age	Gender	Ethnicity	Familiarity	Emotion	N subj	Age (SD)	M/F
Exp. 1	**X**	**X**	**C/Af**			20	25(3)	10/10
Exp. 2		**X**	**C/Af**	**X**		19	22(4)	8/11
Exp. 3	**X**	**X**			**X**	20	25(5)	12/8

Sup Exp 3b (Auditory)	**X**	**X**			**X**	25	29(10)	9/16
Exp. 4		**X**	**As/Af**		**X**	20	24(3)	10/10
Sup Exp. 4b		**X**	**C/Af**		**X**	20	26(4)	10/10
Exp. 5		**X**		**X**	**X**	21	26(11)	11/10
All						**145**	**25.3**	70/75

Each experiment had 3 criteria taken from the set of 5 criteria: Age, Gender, Ethnicity, Familiarity, and Emotions. Each small subgroup was presented with two images (e.g., an Old African Woman could be seen in two images for the Age, Ethnicity, and Gender experiment, though with different faces).

Stimuli selection

The stimuli were chosen from a large data set of images obtained on the internet, and to be sure that each pre-defined criterion was clearly recognized in individual faces, a first set of stimuli was selected to be further validated through a Likert scale. Participants had to indicate whether the face was a man or a woman, an adult or a child, a laughing or a crying face, a known or an unknown face on a scale from 1 to 7 (where for instance, 1 was man, 7 was woman, 4 was completely ambiguous). The direction of the scale was randomly changed for each subject. Rating values were normalized to 7, and only the images presenting the best unambiguous rating (over 5) were selected. Results of the mean rating of the selected faces for each criterion in each experiment are provided in Table 2. Note that, on average, the images obtained a mean value of 6,8 out of 7, meaning that they were strongly unambiguous with respect to the pre-defined criteria (age, gender…). Ratings were conducted on separate groups of subjects (8-10 per experiment) who did not participate in the main categorization study.

Table 2. Ratings of the selected stimuli

	Age	**Gender**	**Ethnicity**	**Familiarity**	**Emotion**	**N subjects**
Exp. 1	**6.8 (0.15)**	**6.7 (0.4)**	**6.8 (0.1)**			10
Exp. 2		**6.0(0.3)**	**6.6(0.2)**	**5.1(0.4)**		10
Exp. 3	**7.0 (0)**	**6.9 (0.08)**			**6.9 (0.11)**	8
Exp. 3b	**6.4 (0.8)**	**6.0 (1.4)**			6.4 (0.5)	10
Exp. 4		**6.8 (0.1)**	**6.9 (0.1)**		**6.6 (0.15)**	10
Exp. 4b		**7 (0.05)**	**6.9 (0.1)**.		**6.8 (0.15)**	10
Exp. 5		**7.0 (0)**		**6.8 (0.8)**	**6.7 (0.7)**	10

Ratings for Age, Gender, Ethnicity, Familiarity are presented for each experiment on the scale 1-7, in which 4 means completely ambiguous, 1 means the extreme feature of one group (e.g., famous for familiarity), 7 means the extreme feature of the other group (e.g., unknown for familiarity). The standard error is presented in brackets.

Experimental procedures

The participant groups were tested in quiet listening rooms at the CerCo laboratory in front of a PC monitor.

Participants' task was to look at the sixteen images and place them dragging with the mouse into groups, i.e., create categories by any means they chose. The size of each image was 100 by 100 pixels, randomly placed in four rows at the top of the monitor screen. Then, once the participants declared that they had accomplished the categorization, they briefly described each category they created using the computer's keyboard. There was no limit on the amount of time given to complete the test, and participants were also allowed to create as many or as few categories as they wished such that a single category could contain only a single stimulus or all sixteen. The experimenter gave no hints or feedback on categories and their number. To assess the recognition of the presented celebrities, we asked the subjects after the experiment which famous people they saw. Besides, they were presented with the same set of images and asked to identify any celebrities.

Testing was conducted using the open-source TCL-LabX software (http://petra.univ-tlse2.fr/tcl-labx/) and Python toolbox pygame.

Data analysis

Two different functions were used in R (FactoMineR package) to analyze the categories that participants created. Hierarchical clustering based on principal components (HCPC) was performed to view a simplified version of the face categories in the form of hierarchical dendrograms, in which the classification levels reflect the level of distinction between the categories (cophenetic distances). Cophenetic correlation coefficients were calculated to estimate the similarities between observations and the corresponding cophenetic distances reflected in the levels of the dendrograms; these correlation coefficients were more than 0.7, meaning that the dendrograms accurately reflect the participants' categorization strategies. Multiple Correspondence Analysis (MCA) was applied to the indicator matrix produced by the

experimental software. The indicator matrix represents the results as an array of categorical variables (participants) as columns and categorical items (stimuli) as rows, with each cell containing a number defining the category membership of each stimulus for each participant. MCA uses Correspondence Analysis (CA) to represent each stimulus as a data point in an n-dimensional Euclidean space based on the categorical values, i.e., the categories made by participants. Each dimension is chosen to account for the largest amount of variance possible within the data set, and dimensions are outputted in descending order of variance covered.

MCA also performs analysis on the participants to find how strongly individual results coincide with the dimensions and, consequently, allows the similarity of participants' categorization strategies to be analyzed (Cadoret et al., 2009). A total of six dimensions were used in the analysis, with those that covered 8% or more of the variance being retained. The two or three most significant dimensions were focused on as they account for the most variance in the data. Importantly dimensions are calculated only to account for variability within the data and are not directly related to any perceptual or physical characteristic of the stimuli or subjects. No a priori knowledge can be used to automatically make such a relation, so a certain amount of interpretation is used when commenting on the dimensions (Cadoret et al., 2009).

To estimate the influence of emotions on the categorization of gender, age, ethnicity, and familiarity, we compared the clusterization of these factors in the protocols with and without emotions. We calculated the Euclidian distances between the points based on their projections to the four eigenvectors, corresponding to the first 4 dimensions of the MCA maps. The distances between points in MCA maps are inversely proportional to the level of their grouping by the subjects (Cadoret et al., 2009). Four dimensions were chosen because, in categorization that includes emotions, other factors are often accounted for only by the 3rd and 4^{th} dimensions. We calculated the distances between the levels of one factor (e.g., between male and female faces for the Gender factor) as well as the distances within each level of the factor (e.g., distances within the group of male faces and the group of female faces for the Gender factor). The significance of the distances was estimated using the bootstrap bias-corrected accelerated confidence intervals at p=0.05.

Results

Hierarchical organization of social categorization, excluding emotions

We first wanted to determine how elementary elements of social categorization drove face clustering. Does a hierarchy exist between the different social attributes of a given face that will apply whatever the stimulus is and that would be shared by all? The categorization would then be first carried out by one rather than the other criterion, which itself would show priority over the next, with, for example, gender being used in priority to ethnicity. Data from experiments not using emotion were then analyzed.

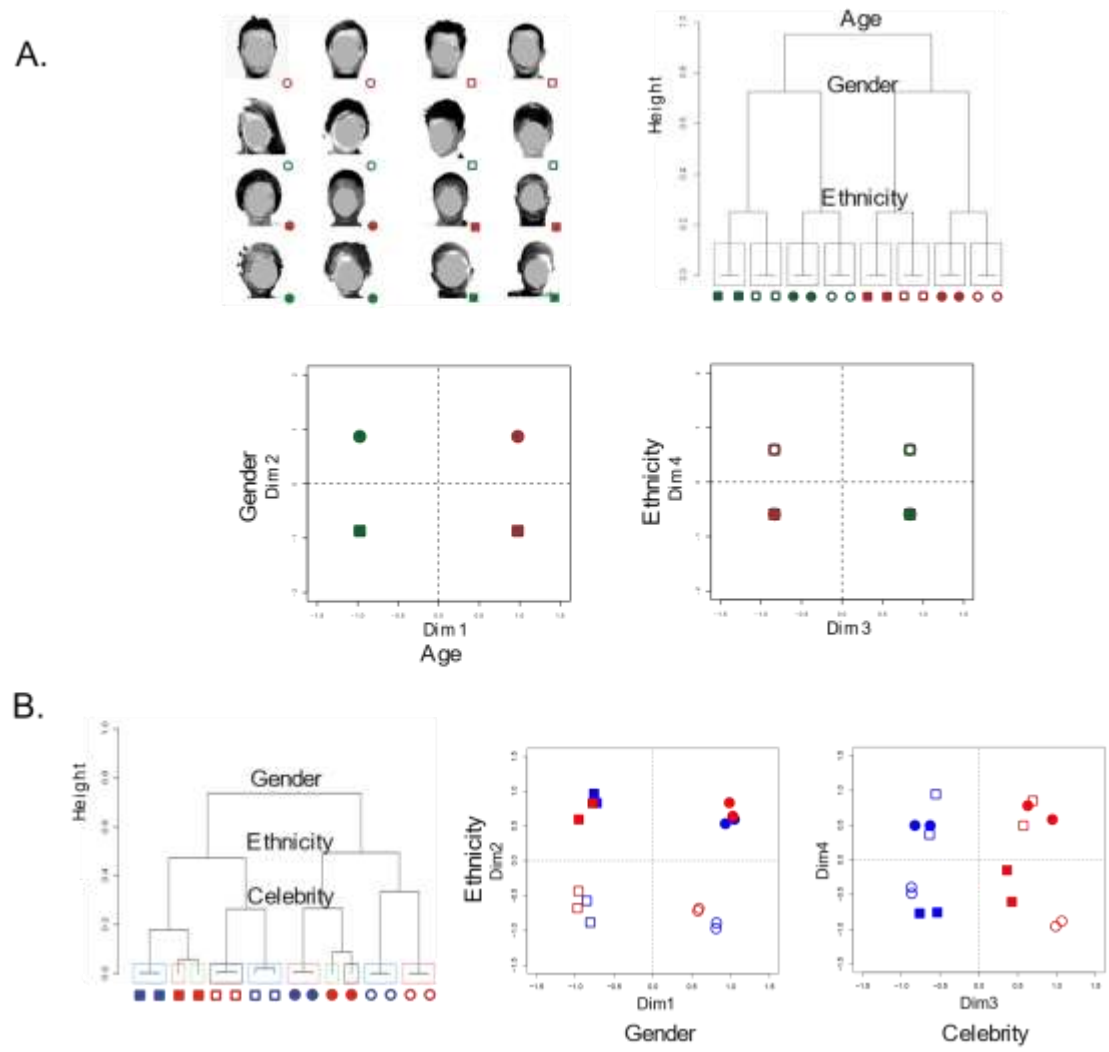
We first proposed a free sorting task (Experiment 1) with faces differing according to age, gender, and ethnicity. Figure 1A represents the set of stimuli with pre-defined categories of age (child, adult), gender (male, female), and ethnicity (African/Caucasian), chosen according to the rating procedure with recognition rates for these criteria that were equivalent (see Table 1). The dendrogram (Figure 1A) shows that the first distinction was according to age: children's faces on the left and adults on the right. Within each age branch, there was a division between males and females. Finally, the third distinction corresponded to ethnicity (African vs Caucasian). It should be noted that the pre-defined number of levels influences the structure of dendrograms, so we will focus on MCA maps, which are a more objective way to visualize the same categorization strategies.

As a result, the participants almost perfectly reproduced the pre-planned categories of the images. This perfect categorization is illustrated by Figure 1A, where stimuli of the same category receive the same coordinates in the MCA maps (lower panel), indicating a high coincidence between participants. The 1st dimension of the MCA accounted for 27.9 % of the variance and represented the separation between child (on the left) and adult (on the right) faces. The highest level of categorization is underlined by the fact that all the points are either at 1 or -1 coordinates of this dimension. It follows that the age factor accounted for the largest percentage of the variance in categorization strategies. The 2nd dimension accounted for 22,1 % of the variance, representing a clear division between male and female; thus, it corresponded to the gender. Finally, the 3rd dimension of the MCA accounted for only 11.5 % of the total variance and corresponded to ethnicity.

Thus, in this first experiment, the predominant factors influencing the categorization were age and gender, which were used respectively by 95 and 75% of subjects; nevertheless, 67% of participants still used the ethnicity criterion. It is important to notice that no instruction was given, and the subjects themselves made this hierarchical clustering. In a few cases,

unexpected supplementary criteria were used, not associated with one of the main pre-defined categories, such as the direction of the gaze or the length of the hairs.

Figure 1. Face categorization for age, ethnicity, familiarity, and gender factors



Panel A, Experiment 1: Age-Gender-Ethnicity. Square – male, circle – female; Filled - African, unfilled – Caucasian; Brown – adult, Green – young. Faces are masked for publication.

In the dendrogram, the first distinction is according to age: children face on the left, adults on the right. Each branch of age has a division between males and females. Finally, the third distinction corresponds to ethnicity (African /Caucasian). In the MCA maps, the 1st dimension accounts for 27.9 % of the variance and represents the separation between child (on the left) and adult (on the right) faces. Thus, the age factor accounts for the largest percentage of the variance in categorization strategies. The highest level of categorization is underlined by the fact that all the points are either at 1 or -1 coordinates of this dimension. The 2nd dimension accounts for 22,1 % of the variance, representing a clear division between male and female; thus, it

corresponds to the gender. Finally, the 3rd dimension of the MCA accounts for 11.5 % of the total variance and corresponds to ethnicity.

Panel B, Experiment 2: Familiarity-Gender-Ethnicity. Square – male, Circle – female; Filled - African, Unfilled –Caucasian; Red – famous, Blue – unknown.

In the dendrogram, the main distinction is gender, then ethnicity, and then celebrity. This can also be observed in the MCA maps where the first criteria used to categorize faces is gender (18% of variance, the criterion used 77% of subjects), then ethnicity (14% of variance and 53% of subjects) and familiarity (14% of variance, 39% of subjects).

As these first data clearly showed a hierarchical organization of the main criteria (age, gender, and ethnicity) used by the participants to make categories, we questioned the place of other criteria, such as familiarity, in this hierarchy. Then we evaluated if a person's familiarity could be the most prominent characteristic of creating social grouping when confronted with the criteria of gender and ethnicity. In this protocol, in terms of familiarity, we have focused our criterion on the celebrity of the people by selecting actors and singers who are very well known in France for this restricted population of young adult subjects (e.g., Marion Cotillard, Rihanna, Jean Dujardin…). The set of 8 well-known celebrities (4 women/4 men) was identified according to the ethnicity criteria and their familiarity status, each rating being unambiguous (see Table 2).

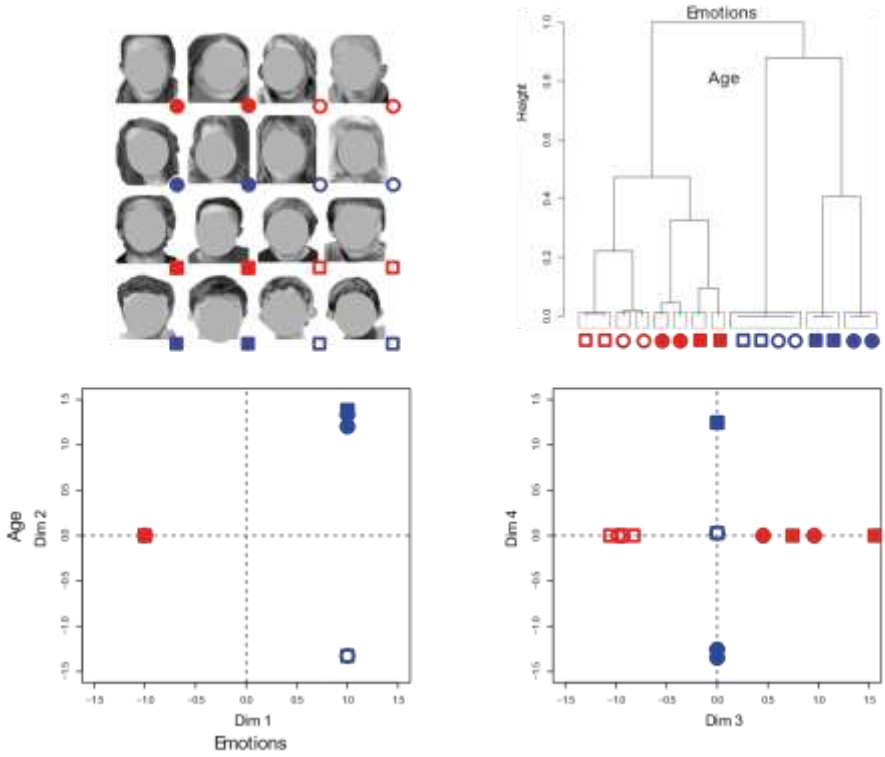
Then, we ran this second experiment (Experiment 2) by presenting, in the free sorting task, adult male and female celebrities (actors and singers) of Caucasian or African ethnicities. In this case, the order of importance for separation according to the dendrogram was gender, ethnicity followed by celebrity (Figure 1B). As illustrated in the MCA maps of Figure 1B, the first criterion used to categorize faces was gender (18% of variance, 77% of subjects). Ethnicity and familiarity were less chosen as a criterion, while ethnicity was slightly more frequently used (14% of variance and 53% of subjects) than familiarity (14% of variance, 39% of subjects). Posterior testing revealed that all participants could recall at least 3 famous faces; each famous face was spontaneously recalled on average by 74% of participants (14 out of 19 participants), who recognized an average of 88% of the presented famous faces (7 out of 8 faces). Thus, while most subjects consciously recognized almost all the famous faces, they used this criterion only as a last choice.

Emotion and social categorization

In the preceding Experiment 1 and 2, it clearly appeared that the participants spontaneously classified the faces according to priorities of social attributes that allowed them to define a hierarchy of categorization: age, gender, ethnicity, and lastly familiarity. Once the hierarchy was clearly established between the more elementary social categories, we wanted to determine how the emotions inferred from the facial expressions could be considered in relation to gender, age, and familiarity. Indeed, given the power of attraction of emotional attributes on social interactions, this order could be modified in the presence of emotion. Therefore, we have repeated both protocols by adding emotion as a pre-defined criterion.

In Experiment 3, this new criterion was confronted with age and gender. Figure 2 represents the set of stimuli with pre-defined categories of emotions (cry, laugh), age (child, adult), and gender (female, male). The dendrogram (Figure 2) shows that the first distinction is according to emotions: laughing faces on the left and crying faces on the right. Within each branch of the emotions, there was a division into adults and children, this distinction being higher for the crying faces as expressed by the height of the branches. The third distinction corresponded to gender but was absent in crying children and very small in laughing children.

Figure 2. Face categorization for the emotions, age and gender factors (Experiment 3)



Square – male, Circle – female; Red – laugh, Blue – cry; Filled - adult, Unfilled –young. Faces are masked for publication.

In the dendrogram, the first distinction reflects emotions: laughing faces on the left and crying faces on the right. Within each branch of the emotions, there is a division into adults and children; this distinction is higher for the crying faces, as expressed by the height of the branches. The third distinction corresponds to gender, but it is absent in crying children and very small in laughing children.

The 1st dimension of the MCA analysis accounts for 23.53 % of the variance and separates between happy (on the left) and sad (on the right) faces. The highest level of categorization is underlined by the fact that all the points are either at 1 or -1 coordinates of this dimension. The 2nd dimension accounts for 20.73 % of the variance, representing a division between crying adults and children; thus, it corresponds to the age factor. The 3rd dimension (11.5 % of total variance) gives a less grouped separation between happy children and happy adults, reflecting the age factor. A slight separation for gender could be found only in the 4th dimension (9.56 % of total variance), where sad adult men's faces and sad adult women's faces were put apart.

The 1st dimension of the MCA analysis accounted for 23.53 % of the variance and represented the separation between happy (on the left) and sad (on the right) faces (Figure 2). The highest level of categorization is underlined by the fact that all the points are either at 1 or -1 coordinates of this dimension. It follows that the emotion factor accounted for the largest percentage of the variance in categorization strategies. The 2nd dimension accounted for 20.73 % of the variance, representing a clear division between crying adults and children; thus, it corresponded to the age factor (Figure 2). As for the 3rd dimension (11.5 % of total variance), there was less separation between happy children and happy adults, reflecting the age factor. Evidence of separation for gender could partly be found only in the 4th dimension (9.56 % of total variance), where sad adult men's faces and sad adult women's faces were put apart (Figure 2).

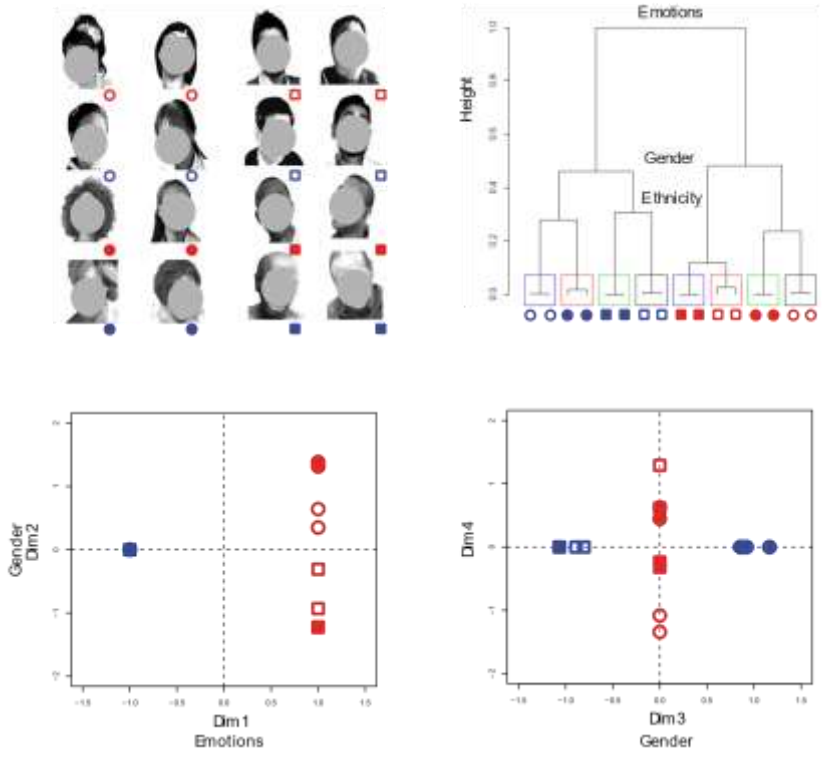
Thus, in this group of subjects doing visual face categorization, the predominant factors (see the subjects map in Sup. Figure 1) which influenced the categorization were emotions and age, which are used by 100 and 85% of subjects, respectively, against only 40% that used the gender criterion. This order of importance is also clearly apparent in the word cloud analysis of the category descriptions (Sup. Figure 5).

Given that the criterion of emotions overtakes the other attributes of social categorization, we wondered if it also overtakes other criteria, such as the ethnicity of the faces, which is one of the main visible social categories for social interactions. As all subjects in our groups belonged to the Caucasian ethnicity, and knowing in social psychology that the in-group/out-group relations can strongly bias the behavioral strategies (e.g. (Taylor and

Moriarty, 1987), in this new protocol (Experiment 4), we selected faces that belong to Asiatic and African ethnicity.

In this case (Figure 3), the first division in the dendrogram was emotions, followed by gender and ethnicity. The most used criterion in the comments to the created categories was emotion in 100% of subjects, then gender (45% of subjects), then ethnicity (25% of subjects). In MCA maps (Figure 3), emotions remained again the main categorization factor (1st dimension, 28.6% of variance) followed by gender (2nd dimension, 14.5% of variance, and the 3rd dimension, 13.3% of variance). The ethnicity factor was associated with gender only marginally in the dimensions of no interest for this study: dimension 5 reflected ethnicity in men (9.15% of variance), and dimension 6 - ethnicity in women (8.26% of variance).

Figure 3. Face categorization for the emotions, ethnicity, and gender factors



Square – male, Circle – female; Red – laugh, Blue – cry; Filled - African, Unfilled –Asian.

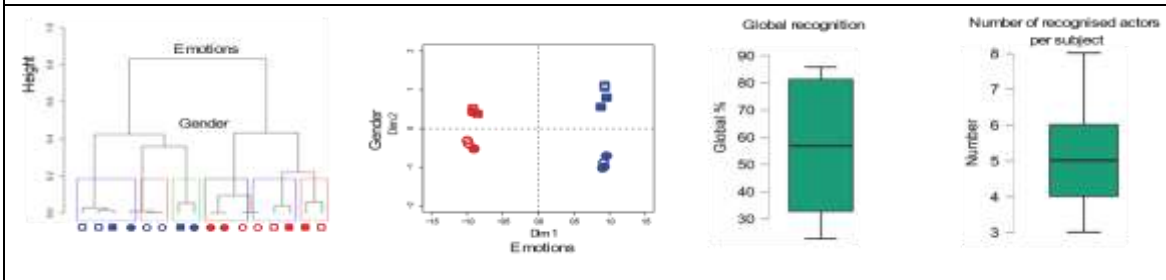
The first division in the dendrogram is emotions, followed by gender and ethnicity. In MCA maps, emotions remain the main categorization factor for the 1st dimension (28.6% of variance), followed by gender in the 2nd dimension (14.5% of variance). The ethnicity factor was associated with gender only marginally, in the dimensions of no interest for this study.

When, in a different group, we proposed African versus Caucasian ethnicity (Experiment 4b, see Sup Mat), the last being the ethnic group of all the subjects who participated in the task, we observed a similar global categorization (see Sup. Materials, Sup. Figure 2). The most used criterion in the comments to the created categories still was emotions (100% of participants), then gender (20% of participants), then ethnicity (15% of participants).

The three previous experiments demonstrated that emotion was the main criterion used before age, gender, and ethnicity. We finally evaluated if the hierarchy of categorization previously observed was disturbed when confronted with the criterion of familiarity added to gender and emotion (laughing and crying people). The set of 8 well-known celebrities (4 women/4 men, e.g., J. Dujardin, M. Cotillard, Mimie Mathy) was initially clearly identified according to the emotion criteria and their celebrity status, each rating being close to the maximum (6.7 and 6.8 respectively out of 7.0 being the maximum of compliance with the criterion see Table 2).

Again, the results of Experiment 5 (Figure 4) confirmed the previous analysis: in the dendrogram, the first branching was emotions and gender; the most used criterion to create categories was emotion (95% of subjects), then gender (43% of subjects), and then familiarity (10% of subjects). This order is apparent in the MCA (Figure 4), as emotion constitutes the greatest dimension (26.8% of variance) followed by gender (16.1%) and then only as a minor factor by familiarity (5.8%) only detectable in the dimensions of weaker interest (the 6th dimension). Considering the individual responses, 81 % of participants used the criterion of emotion for categorization, 43% used the criterion of gender, and 14 % used the familiarity criterion.

Figure 4. Face categorization for the emotions, familiarity, and gender factors



Square – male, Circle – female; Red – laugh, Blue – cry; Filled - famous, Unfilled –infamous. Global recognition is the percent of recognized actors, while the number of recognized actors indicates the number per subject out of 8 presented actors.

In the dendrogram, the first branching was emotions, followed by gender. In the MCA maps, emotions constitute the predominant dimension (26.8% of variance), followed by gender (16.1%). Familiarity was not accounted for by four dimensions. Each actor was recognized by the subjects in 66% (±26%, SD) of cases, and the average number of named actors per participant was 5.3 (±1.5, SD) out of a maximum of 8.

As familiarity turned out to be a minor factor quite unexpected, it was important to assess if the participants were aware that half of the faces corresponded to famous French actors. Indeed, after completing the FST, in the follow-up questionnaire, the subjects were able to recall and name from memory at least three of the celebrities. Each actor was recognized by the subjects in 66% (±26%, SD) of cases, and the average number of named actors per participant was 5.3 (±1.5, SD) out of a maximum of 8. This indicates that the faces were consciously perceived as being famous individuals, but the subjects weakly used this criterion for categorization. Thus, the predominance of emotional facial expressions remains when the age factor is excluded, and celebrity is introduced. However, despite being sufficiently well-perceived, the celebrity had minor subjective importance as a category.

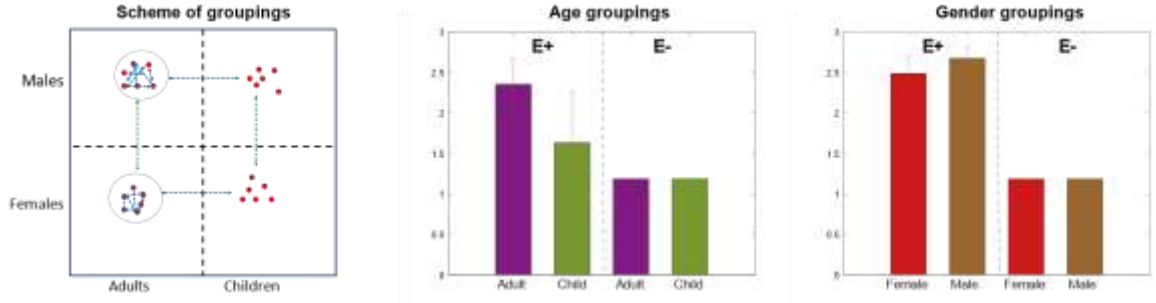
Hierarchical ranking of social categorization

These first data allowed us to organize the criteria that the participants chose to make categories in hierarchical order. From the experiments, results suggest that the order of importance to categorize faces is, therefore, age, gender, ethnicity, and then familiarity. Moreover, the hierarchy between the different criteria seems to resist variations in the initial choice of these criteria. While the age category was dropped between the first and second experiments and replaced by familiarity, the ranking between gender and ethnicity was preserved. However, the 3 last protocols demonstrated that the emotion of faces was the first criterion used to make categories. Moreover, we find exactly the same order between categories when the faces were carrying emotions (Experiments 3 to 5) than when they did not (Experiments 1 and 2), but in this case, the categorization of the emotional attributes is placed on top. However, we observed that emotional attributes of the face tend to reduce the distinction between other social categories in agreement with the notion of interactions and competition in cases of multiple categories (Craig and Lipp, 2018). To better evaluate the

direct interaction of the multiple criteria for social categorization, we calculated the distances between (segregation) and inside (grouping) categories (see Methods section).

We found that in the presence of emotions, the distances within the formed categories (Gender, Age) were significantly higher than those without emotions, meaning that stimuli within social categories are less grouped, i.e., more dispersed, under the influence of emotional expressions. This is clearly present in the grouping values for age and gender (Figure 5) when comparing the task that includes the emotion (Experiment 3) with the one in which the emotion was absent (with ethnicity Exp 1). In both cases (gender and age), there is a significant decrease in grouping faces (decrease of intra-group distances, $p<0.05$) within the same category when emotions are present. A similar result is observed for ethnicity (see Sup. Figure 4).

Figure 5. Grouping values of Age (left) or Gender (right) criteria when the emotion is present or absent



The results on groupings are from Experiment 1 (Emotions present, E+) and Experiment 5 (Emotions absent E-).

There is a significant decrease in grouping faces (decrease of intra-group distances, $p<0.05$) within the same category when emotions are present.

Hierarchical ranking and sensory processing

A hypothesis in the case of multiple categories embedded in a single item is that the most salient category will prevail and influence the choice of subjects. In order to test this possibility, we investigated whether low-level visual characteristics could be at the origin of this hierarchy. Firstly, we search whether such a hierarchical categorization could be modality dependent. As a voice has been described as an auditory face (Campanella and Belin 2007), we run an auditory FST using the 3 main a priori criteria (age, gender, and emotion). In this case, we observed exactly the same ranking when participants had to categorize voices instead of faces (Sup. Figure 3).

Further, a second way of assessing this hypothesis was to develop a face Go/no Go discrimination task according to the 3 main categories (age, gender, and ethnicity, see Sup. Materials for details). When subjects have to discriminate one of these three attributes, it appears that gender is the fastest (and most correctly recognized) while age discrimination is the slowest ($p<.05$), ethnicity being intermediate. Thus, when looking at such performance level (see Sup. Figure 6), gender recognition is ranked first and age third, opposite to that observed in the social categorization ranking.

These two additional protocols confirmed that the hierarchical organization observed in the FST is not dependent on low-level perceptual features that could provide a higher saliency to one of the categories.

Discussion

In the present study, we sought to find out whether priorities existed in representing social traits, and for this, we used an original method that differs from the protocols usually used in social psychology. Using a Free Sorting Task approach, we were able to propose the existence of a hierarchy of categorization when exposed to a face, namely first the age, then the gender, and subsequently ethnicity and familiarity equally. Furthermore, the representation of facial expressions, allowing one to infer a person's emotional state, overwhelmingly outperforms all other social information without changing the processing order of the other categories. These results are in some respects in contradiction with previous studies on automatic social categorization rules, but they do provide new information on the nature of social categorization when we are exposed to a person.

Hierarchy within multiple social categorizations

It was strongly claimed that the social categorization process is an automatic mechanism spontaneously activated when one meets a person. This categorization will then determine our social relations, guided by our beliefs and priors about specific social categories in many situations. The real challenge the investigators face is understanding how categorization is achieved when there are multiple alternatives such as gender, ethnicity, age, sexual orientation, religious affiliation, occupation…. Several models of crossed categorization have been proposed (see (Hewstone et al., 1991)) in which categories interact jointly (additive model) or converge to create a new category subtype (interactive model). An alternative

possibility refers to a hierarchical model in which one modality dominates over the others but leaves the possibility for other categories to influence behaviors, albeit in a more limited way (Echebarria Echabe and Fernández Guede, 2006). In all these models, inhibitory mechanisms are involved, which have been established mainly using priming paradigms and speeded response tasks (Macrae et al., 1995). One of the problems is that there are many pieces of evidence that cross-categorization is strongly context-dependent (for example, the instructions), a bias which is not present in our FST protocol. In addition, no studies have explored crossed categorization effects with no more than two categories; a possibility that we have been able to developed using the FST.

When going across the social categorization literature, there is a consensus that gender, ethnicity, and age are processed automatically because of their high saliency in our surrounding environment, although a debate persists concerning ethnicity (Cosmides et al., 2003). Our results clearly show that these three visible traits do not proceed with the same priority or prominence. In the basic condition (with age, gender, and ethnicity pre-defined, Exp1), the age criterion is used by almost all subjects (95%), far above the proportion of subjects that selected the two other criteria. Further, when facial expression is introduced among the pre-defined criteria, the proportion of subjects that selected age as a category remains much higher than the criteria of gender. Such a result is a strong argument for hierarchical processing. Indeed, when we add or remove one criterion across protocols, the ordering relationships between the other features do not change. When comparing Exp1, Exp2, and 4, "gender" is chosen more frequently than "ethnicity," or when comparing Exp1 and 3, "age" is selected more frequently than "gender". Lastly, the hierarchical order in selecting the different categories is not restricted to the visual modality. When comparing Exp3 (visual face presentation) and Exp3B (auditory voice stimuli), we observed the same order in the hierarchical tree, which perfectly demonstrates amodal hierarchical processing. In the auditory situation, the distance between social traits is slightly different, probably because the pitch differences in voices are not as salient in differentiating age or gender as the visual characteristics present in a face.

Bottom-up and top-down mechanisms of social categorization

As mentioned, our study is the first to establish a hierarchy in processing the different social features used to categorize a person. Indeed, most of the previous studies used a

priming protocol giving different contexts that preclude making direct comparisons. Based on the analysis of the RTs during a discrimination task, a large body of studies claims that a face's expressive features are processed after age, gender, and even ethnicity. Such assumption relies on the fact that facial expression categorization is largely influenced (speed and accuracy) by age, gender, or even familiarity with individuals (see (Carr et al., 2017; Craig and Lipp, 2018)). However, such relative delay in categorizing facial expressions could be due to an ambiguous treatment of facial characteristics, which brings the problem back to a more basic visual processing issue. This type of problem does not apply to FST, during which subjects have all the time to examine and group the faces. Indeed, when the familiarity criterion is introduced, a categorization based on the famous faces is weakly present, while a post-test checking revealed that subjects clearly recognized the famous faces and could name almost all of these celebrities from memory. This indicates that the strategy truly reflects social categorization and is not dependent on low or high levels of sensory processing.

Lastly, to definitively discard the influence of visual processing mechanisms, we performed a discrimination task on three criteria using the same set of about 200 faces. And indeed, the ranking in terms of speed and accuracy of processing was inverted as the gender of the face was more rapidly categorized compared to the age.

Altogether, our results contradict previous studies on social categorization that could be resumed as implicit categorization tasks. On the opposite, the FST is characterized as an explicit process, during which the subjects analyze each face and make explicit grouping taking into account multiple internal representations of the social attributes of the face resulting from top-down mechanisms. Our approach is compatible with the hypothesis that social categorization is a dynamic process that results from bottom-up and top-down interactions (see (Freeman and Johnson, 2016)), suggesting that multiple categories could be simultaneously activated independently of the outcomes.

Role of emotion in social interactions

There is a large and lively debate about the links between cognition and emotion processing which opposes the adherents of an affective primacy hypothesis to those of a cognitive primacy hypothesis (Storbeck and Clore, 2007). Such dissociation is, again, based on a processing analysis of the speed with which affective or non-affective information can be activated (LeDoux, 1996; Murphy and Zajonc, 1993). Many arguments support both

hypotheses, but everyone agrees on the dependency and interactions between these two processes. Here we demonstrate that facial expressions are prioritized when subjects have to categorize a face without instruction, which emphasizes their crucial role in social cognition. With hindsight, our results are not so surprising when we know how the processing of facial expressions is important as it allows us to adjust our behavior in the presence of a person, to infer his intention towards us but also to analyze the situation in which we find ourselves (See (Frith, 2009)). It is established that the facial expression carried by a face attracts attention, elicits a corresponding emotional sensation, and can also modulate our state of vigilance about the current environment (Frith, 2009). At the developmental stage, processing facial expressions is also extremely important and participates in cognitive development through the phenomenon of mimicry, which permits the developing neonate to structure its ability to understand the mental state of others (Tramacere and Ferrari, 2016).

In the present study, we used two highly visible and antagonistic facial expressions, happiness and sadness, and such dichotomy or dual valence context (which also applies to the other criteria) could be problematic if we want to generalize the influence and importance of emotional information on social categorization (see (Bijlstra et al., 2019)). It would be interesting to evaluate, in a FST, how the categorization would be performed using other facial information such as hanger, fear, or any of the different visible emotional expressions. Further, knowing that not all expressive features are equally well recognized and that they do not have the same effectiveness in bringing out a feeling, it would be interesting to analyze how subjects process when presented with different facial expressions leading to the inference of emotions which can have different valences (happiness, fear or disgust for example).

In this paper, we have voluntarily made a distinction between what we have considered social categories, as they are classically referred to, namely gender, age, ethnicity, and familiarity, and the different facial expressions shown by individuals. Indeed, studies examining social categorization do not include facial expressions in their criteria. One explanation could be that unlike other characteristics such as age, gender, or ethnicity, which can be perceived as more stable dispositions or even "traits" of individuals, facial expression is a more dynamic feature and could reflect a more transient state, that can even, in some cases, be a voluntary process. Individuals can successfully and quickly present very different expressions, while he/she cannot voluntarily change age, gender, or ethnicity! However, this

possibility of categorizing faces according to all these criteria seemed crucial to us if we placed ourselves in the context of social interactions. Not only will the quality of our social interactions depend on our ability to categorize our interlocutors according to criteria shared and intrinsic to each individual, such as their age, gender, ethnicity, or the bond that unites us with them, but also by our ability to infer emotions from the facial expressions they display. Only then will we be able to make appropriate expectations about others and adapt our behavior. By showing the universality and importance of categorizing faces according to facial expression, our results lead us to reconsider this position. Despite their dynamic and temporary nature, facial expressions could constitute social categories in the same way as age or gender! Such a proposition agrees with the constructivist approach, which considers emotions socially constructed (see (Tcherkassof and Dupré, 2021). This approach suggests that emotions are "interpreted" according to our knowledge and social representations. In other words, facial expression would be a social cue that would be the subject of inferences about a person's emotional state. The physical characteristics of the facial expression itself would not purely determine these inferences. They may be influenced by other factors, including our emotional states or level of familiarity with that person, thus by our social category memberships.

Free sorting Task and ingroup/outgroup belonging

One of the main principles of social categorization is that it increases differences between groups while it reduces differences inside the groups; in this way, social categorization is self-referential. Then the formation of categories will depend on this ingroup or outgroup belonging. Using the visible criteria of age, gender, and ethnicity or familiarity in addition to the facial expression, we did not observe an effect of the sex of the participants in making any kind of categorization. However, we have indications that the subjects' ethnic affiliation (all Caucasian in our study) influenced their choice of grouping. Indeed, by comparing Exp4 and 4B, we observed that the criterion of ethnicity was much less used when some of the stimuli belonged to the 'Caucasian' category than when the classification was made between two other ethnic groups. (15% vs 25% respectively). After completing the test, the collection of some participants' comments shows that the ethnicity criterion has sometimes been consciously dropped. This choice was probably dictated by moral considerations, considering that the clustering of faces concerning ethnicity was considered

not politically correct in our population of participants. Such observation confirms that the ingroup influence is observed using the FST as in other protocols previously used to evaluate social categorization. To minimize such in/out-group influence, we designed our experimental protocol by recruiting only students of the same age and similar academic levels.

Conclusions

Our data demonstrate a hierarchical organization of the basic social feature of a face, naming the age, gender, and ethnicity. Such hierarchical ranking is obtained during a specific task, the FST, a protocol with no constraints regarding categories to be considered and information processing speed. In this way, our data provide information on top-down processes that impact social vision mechanisms (Stolier and Freeman, 2016). The most striking point is that the FST gives extremely robust results and that most subjects follow the same strategies despite the likely (cultural) and established (gender) differences between them. One open question raised by these results is their consequence in terms of behavioral outcomes. The notion that a specific social trait can dominate because it is placed at the top of the hierarchy implies that this social information could be the one that triggers in priority the most appropriate behavior. Our data does not provide any positive answer to this hypothesis, although the fact that emotion outclasses all the other categories might suggest it since facial expressions have an important role in social interactions (Frith, 2009). Further, this raises the question of whether facial emotions can be considered a social category in the proper sense of the term. The intrinsic nature of facial expressions, which are dynamic and evolve, contrasts with other invariant characteristics of facial information (gender, age, etc.), even if their sometimes ambiguous features can also be dynamic and induce that social categorization processing evolves in time.

Altogether, we are convinced that the social categorization approached through the FST will enable an almost limitless exploration of the multiple social categorization processing.

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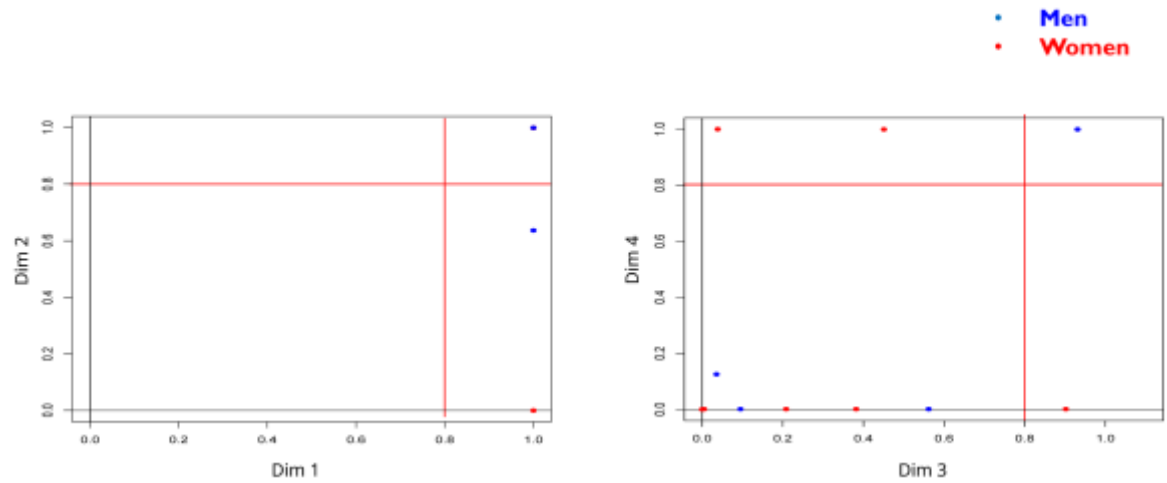
Supplementary materials

Age/Gender/Emotions, Experiment 3

Subject Map

To assess the homogeneity of categorization, analysis was performed on the factor maps derived from the populations of participants with respect to the 4 principal dimensions. Taking an arbitrary value of 0.8, the analysis showed that most subjects used the Emotion (Dim 1) and Age criterion (Dim 2). The choice of the criteria of Gender, present in both Dim 3 and Dim 4, is less consistent across subjects. No differences between men's and women's strategies were found.

Supplementary Figure 1. The usage of the dimensions for Age/Gender/Emotions by the subjects (Experiment 3)



The majority of subjects used the Emotion (Dim 1) and Age criterion (Dim 2) according to the arbitrary threshold (0.8) indicated by the red line. For the high level of categorization, subjects are often presented at the same point giving the number of points less than the number of subjects.

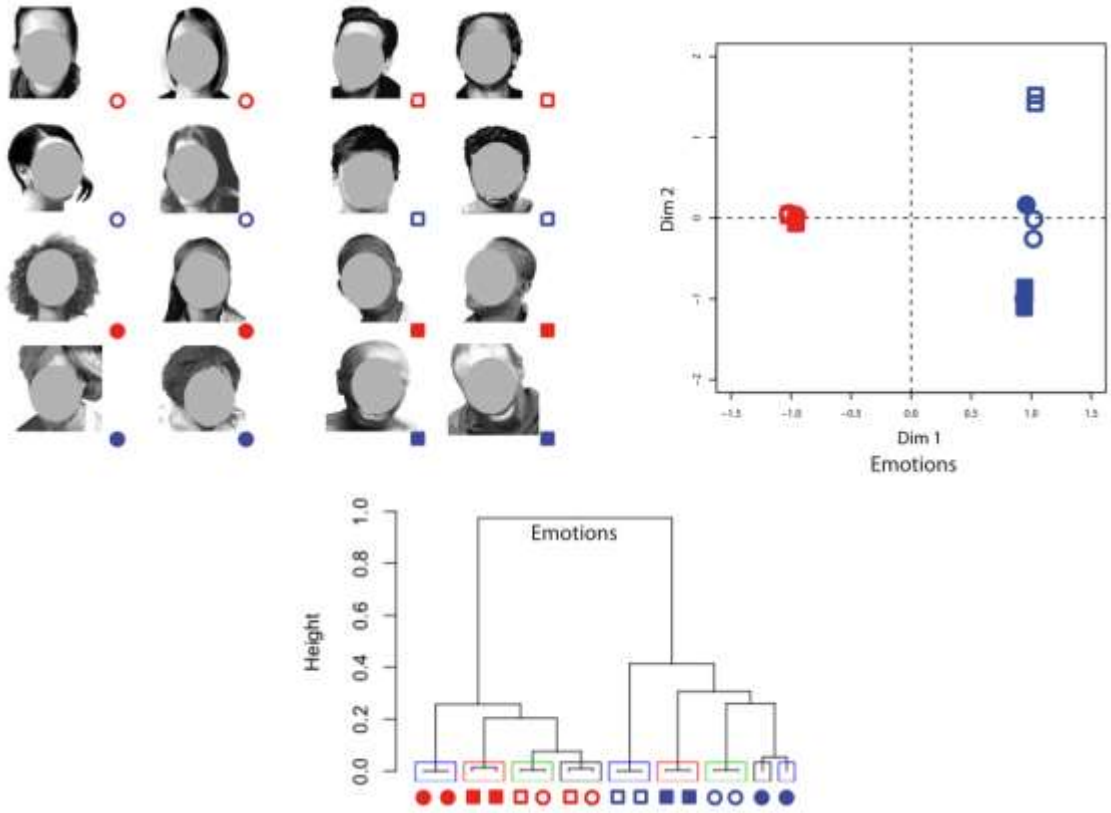
Word cloud

In the group of subjects who performed visual face categorization with this set of stimuli, according to the subjects' comments on the created categories, the most used criterion was emotions (in 100% of subjects), then Age (55% of subjects), then Gender (35% of subjects). The raw data concerning the comments can also be visualized with Word clouds (Sup. Figure 5).

Emotions/Gender/Ethnicity (African-Caucasian), Experiment 4b

In this case, the most used criterion in the comments to the created categories was Emotion in 100% of participants, then Gender (45% of subjects), then Ethnicity (25% of participants). In MCA maps, emotions remained again the main categorization factor (1st dimension, 28.6% of variance) followed by Gender (2nd dimension, 14.5% of variance, and the 3rd dimension, 13.3% of variance). The Ethnicity factor was associated with Gender in the next dimensions: dimension 5 reflected ethnicity in men (9.15% of variance) and dimension 6 ethnicity in women (8.26% variance).

Supplementary Figure 2. Effect of different Ethnicity on emotions and Gender.



Square – male, Circle – female; Red – laugh, Blue – cry; Filled - African, Unfilled –Caucasian. Faces hidden for publication. Emotions remained again the main categorization factor (1st dimension, 28.6% of variance, 95% of participants) followed by Gender (2nd dimension, 14.5% of variance, 85 and the 3rd dimension, 13.3% of variance).

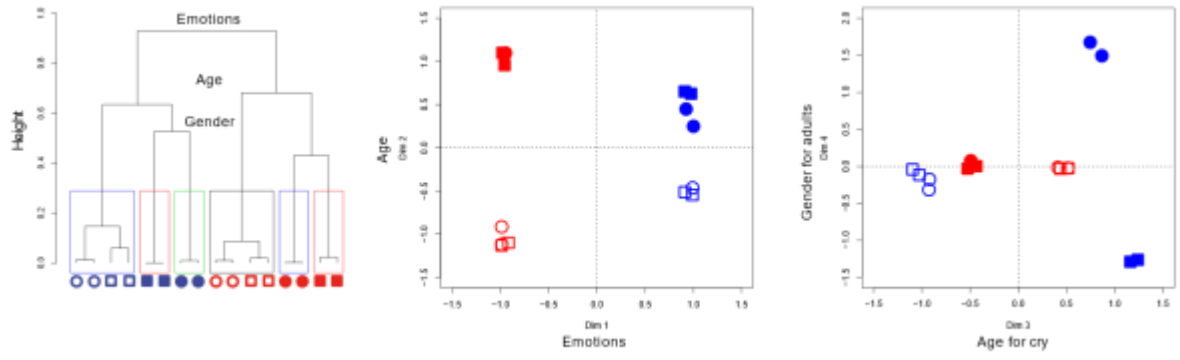
The fact that the categorization organization is not as clear as in the previous protocols is probably due to the fact that some subjects censored themselves from applying a choice based on Ethnicity while others did not.

Age/Gender/Emotions in voices, Experiment 3b

An auditory free sorting task was proposed to a new group of participants. Sounds were presented in stereo, with Sennheiser HD 280 pro headphones, at a subjectively comfortable level adjusted for each participant. The sixteen voice sounds were represented on the computer by sixteen numbered and colored squares without any image. Sounds were played by using the PC mouse to double-click on each square. Participants were asked to run a sound categorization task, creating categories by dragging and positioning squares together on the screen. There was no limit on the amount of time given to complete the test or the number of times a specific sound could be listened to (the number of playbacks).

Concerning voices, the approach to the rating according to some factors was more lenient due to the natural resemblances of pitch: the voices of boys and girls are hardly distinguishable (rating of Gender for children voices 4.7±0.5, SD), while the distinction of Gender in adult voices is high: (gender rating 6.9±0.2). This constitutes a certain limitation of the auditory study. Table 1 presents the average value between the adult and children's voices (5.8±1.8).

Supplementary Figure 3. Voice categorization with Emotion-Age-Gender factors

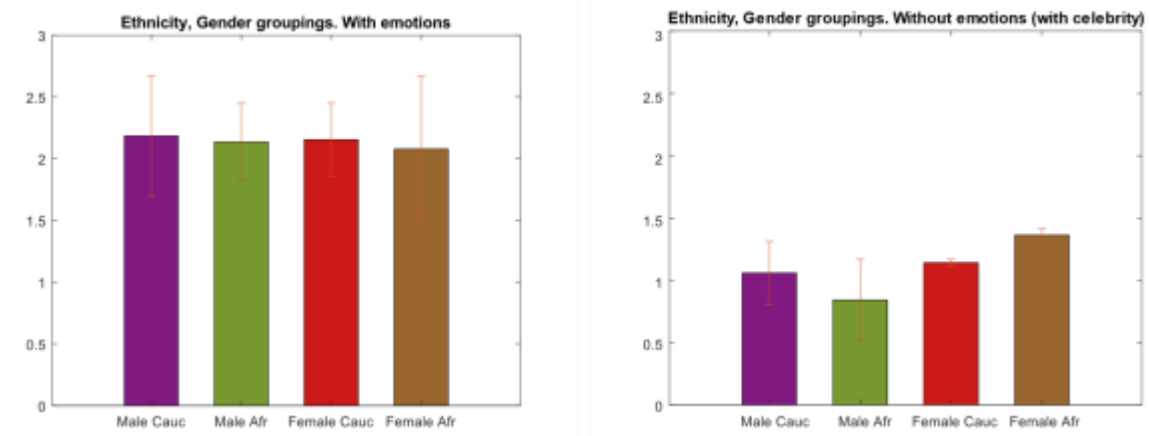


Results of categorization for voices: a dendrogram and the MCA maps for the 4 dimensions.
Square – male, Circle – female; Red – laugh, Blue – cry; Filled - old, Unfilled –young. Emotions have the most important distinction, followed by Age and Gender, in the same way as for the visual stimuli. However, in children, there is no distinction between genders in voice.

Euclidian distances for different factors within the groups

To measure the grouping of points, Euclidian distances between all the points were calculated for the first three dimensions for categorization results. These distances were compared for all the categories in the categorization results.

Supplementary Figure 4. Effect on categories grouping



On the left are the distances between stimuli in the presence of emotional expressions. On the right are the distances between the stimuli of the same categories for the neutral faces. In each category, the distances between the images were smaller in the absence of emotions ($p<0.05$, bootstrap).

Effect on categories segregation

As for the distances between the groups, they were modified by emotions only for the Gender (between males and females) and for the Ethnicity (between Africans and Caucasians) factors. However, the between-group separation is only an indirect estimation because the distances in MCA maps mainly reflect the grouping level: the points are close as they are placed in the same group by many subjects.

In addition, if we consider Emotion only, the grouping for this factor is similar to other factors in the experiments with emotions; however, the grouping for emotions is less pronounced than for different factors (Age, Gender, Ethnicity, Celebrity) in the experiments without emotions. Thus, in the experiments with emotions, all the categories are less grouped together than in the experiments without emotions.

Supplementary Figure 5. Word clouds for the comments made by the subjects for the categories.

Emotions, age, gender

Exp.3

Emotions, age, gender, in voices

Exp.3b

Emotions, gender, different ethnicity

Exp.4

Emotions, gender, same ethnicity

Exp.4b

Emotions, gender, familiarity

Exp.5

Emotions, gender, same ethnicity

Exp.1

Gender, familiarity, same ethnicity

Exp.2

In the experiments with facial emotions present, they are the most frequent words used in the comments on the formed groups. Emotional descriptors were not used to describe the groups in the experiments without facial emotions.

Go/no Go Discrimination task and Reaction time for social categories

A supplementary set of 12 subjects who did not participate in the FST were recruited (7 women, Age 26±6 (SD)) to perform a discrimination task of facial attributes corresponding to the 3 main social categories previously used, namely Gender, Ethnicity, and Age.

The visual stimuli were a set of 96 human faces obtained from the American Multiracial Faces Database (Chen et al., 2021). The set consisted of adult or children faces of African or Caucasian Ethnicity, making 48 male and 48 female, 48 children, and 48 adults, and 48 African and 48 Caucasian altogether. All images were normalized for contrast and luminance and were presented twice for each task in a random order resulting in 192 presentations for each task.

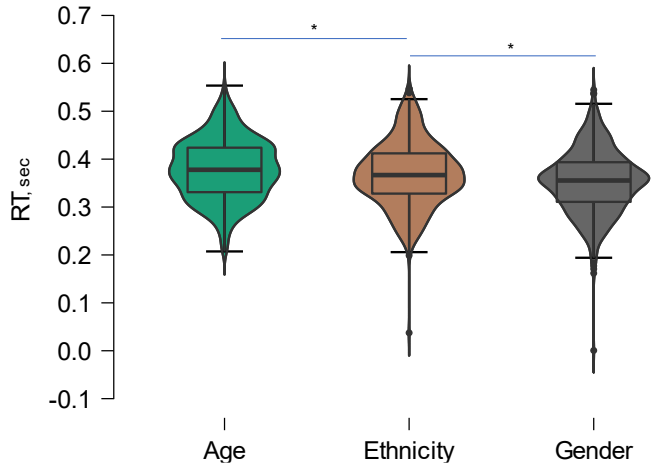
The task is a Go/no Go discrimination task in which the subjects had to press a button as fast as possible when the face corresponds to the Go criteria. In the first task, the Go criterion was the Gender (press if the face is a man); in the second task, the Go criterion was the Age (press if the face is a child); in the third task, the Go criteria was the Ethnicity (press if the face is a Caucasian). The order of the Go criteria (Age, Gender, and Ethnicity) was randomly balanced for each subject as well as the target (men vs. women, children vs. adults, African vs. Caucasian).

Images were presented on a monitor screen for a duration of 50 ms, with a maximum time of 500 ms to respond and 700 ms of inter-trial delays. Anticipation trials (RTs values lower than 20 ms) were excluded from the analysis.

The analysis showed that Gender is the most recognized criterion (56,5% Hits), followed by Ethnicity (48,7% Hits) and Age (47,1% Hits). Using the linear model with repeated measures (lme4 package in R) estimated by Anova (car package in R) with Tukey post hoc tests, we found a significant difference between Gander and Ethnicity ($p<0.001$) as well as between Gender and Age ($p<0.001$).

Similarly, we observed a statistical difference between the RTS for each criterion, gender discrimination being the faster (0.35 ms) compared to Ethnicity (0.37 ms) and Age (0.38 ms). Using the linear model with repeated measures (lme4 package in R) estimated by Anova (car package in R) with Tukey post hoc tests, we found a significant difference between Gander and Ethnicity ($p<0.001$), Age, and Ethnicity ($p<0.05$), as well as between Gender and Age ($p<0.001$).

Supplementary Figure 6. Reaction times for Age, Gender and ethnicity



When subjects have to discriminate between Age, Gender, and Ethnicity, it appears that Gender is the fastest, while age discrimination is the slowest, with Ethnicity being intermediate.

References

Chen, J.M., Norman, J.B., Nam, Y., 2021. Broadening the stimulus set: Introducing the American Multiracial Faces Database. Behav Res 53, 371–389. https://doi.org/10.3758/s13428-020-01447-8